Summary of Suggested Options for the Elements of the Combined NOx and SOx Secondary NAAQS

INDICATOR
NOx: NOy (total oxidized nitrogen, including NO_2 + NO + HNO_3 + PAN +$2N_2O_5$ + HONO + NO_3 + organic nitrates + particulate NO_3) SOx: SO_2 + SO_4
AVERAGING TIME
3 to 5 year averaging time (3 to 5 year averages of annual average NOy and SO2+SO4) selected based on interannual variability in deposition as reflected in components the form (see below).
FORM
The form for the secondary standards incorporates multiple design decisions, including treatment of combined effects of NOx and SOx, selection of an ecological indicator of effects, treatment of reduced forms of nitrogen, and treatment of natural ecological conditions that affect sensitivity to acidification. • Treatment of combined effects of NOx and SOx: Conversion to acid deposition units (in meq/m^2/year) through application of "transference ratios" based on modeled ratios of atmospheric concentrations to deposition. • Ecological Indicator: Acid Neutralizing Capacity • Treatment of reduced forms of nitrogen: Incorporated into the form as an adjustment to the nitrogen balance of the ecosystem • Treatment of natural ecological conditions: In order to focus on sites which are acidic due to atmospheric deposition of NOx and SOx, those sites which are acidic due to low weathering rates of base cations as indicated by modeled pre-industrial base cation weathering $[BC]_O^*$, high organic inputs based on dissolved organic carbon (DOC) concentrations and acid mine drainage based on sulfate concentrations were removed from the critical loads dataset. Of the sites included in further analysis, nitrogen uptake and retention (Neco) are used to account for natural ability of ecosystems to neutralize acid deposition. The result of these design decisions is a form for the ambient air quality standard that ties ANC to deposition and deposition to ambient air concentrations, incorporating ecological conditions and the contribution of reduced nitrogen. To incorporate all of these aspects, we

developed an index that would provide a consistent number nationally that is directly expressed in terms of concentrations of NOx and SOx. This index is called the Atmospheric Acidification Protection Index (AAPI).

The formula for the APPI is derived from the critical load equation for a single catchment (eq 2, section 5.3.2) for a selected target value of ANC ($ANC_{\lim}$):

$$CL_{ANC\lim}(N+S) = ([BC]_O^* - [ANC_{\lim}])Q - Neco$$

The AAPI is derived by rearranging Equation 2 to solve for $ANC_{\lim}$, and replacing the values of $[BC]_O^*$, Q, and Neco with the values for waterbodies representing specific percentiles of the distribution of critical loads across a population of catchments.

$$AAPI = \left[[BC]_O^*\right]_{\%eco} + \frac{1}{Q_{\%eco}} \cdot Neco_{average} - \frac{1}{Q_{\%eco}} \cdot Dep_{NHx}^{Total} - \frac{1}{Q_{\%eco}} \cdot \left[T_{NOy} \cdot C_{NOy} + T_{SOx} \cdot C_{SOx}\right]$$

The AAPI is essentially a function that determines whether ambient NOy and SO_2 + SO_4 are expected to achieve a target ANC limit. The AAPI value selected as the level of the standard will be based on the target ANC limit, given uncertainties in the parameters used to calculate the AAPI, and weighing other factors such as time to recovery for ecosystems. (eq 17, section 5.3.4)

For a selected level of AAPI and specific values of the $\left[[BC]_O^*\right]_{\%eco}$, $Q_{\%eco}$, $Neco_{average}$, and Dep_{NHx}^{Total}, the combinations of NOy and SO2+SO4 levels that result in attainment of the AAPI can also be expressed as a tradeoff curve. The level of the AAPI will be one value that applies to the entire nation, however the degree to which the values input to parameterize the equation (e.g. $\left[[BC]_O^*\right]_{\%eco}$, $Q_{\%eco}$, $Neco_{average}$, and Dep_{NHx}^{Total}) will vary according to which options of spatial aggregation are chosen (see below). These options will also affect the variability in the resultant tradeoff curves.

Spatial aggregation options for the components of the AAPI equation						
	Op#1 No subdivision of the U.S.	Op#2a Binary categorization	Op#2b 5 Cluster	Op#2c 1 sensitive category and individual sensitive eco-regions	Op#2d All individual ecoregions	Other options
The critical loads ($CL_{anclim}(N+S)$) from individual catchments will be aggregated to form a population. From the distribution of CL values in the population, a percentile of the distribution will be selected as the deposition metric ($DL_{\%eco}(i)$). The population to which an individual site belongs varies among the spatial aggregation options. The following terms are those associated with the critical load that represents the selected $DL_{\%eco}(i)$. Pre-industrial base cation weathering $\left[[BC]_O^*\right]_{\%eco}$ is the value from the individual critical load that is selected as the $DL_{\%eco}(i)$. Runoff $Q_{\%eco}$ is the value from the individual critical load that is selected as the $DL_{\%eco}(i)$.	X	X	X	X	X	
N removed by an ecosystem($Neco_{average}$) These are calculated from N deposition values averaged over a 3-5 year time period. Staff suggest the spatial area of aggregation should be consistent with $DL_{\%eco}(i)$	X	X	X	X	X	
Reduced N deposition (Dep_{NHx}^{Total})are modeled and averaged over a 3-5 yr time period, options for spatial aggregation are listed on the table					X	Model averaged to match areas of spatial homogeneity (See figure 5-16), so that each ecoregions would possibly have multiple NHx values
Transference ratios (T_{SOx} and T_{NOy}) are the					X	Averaged over the areas represented

aggregated effective deposition velocities. These values are modeled and averaged over a 3-5 yr time period, options for spatial aggregation are listed on the table						by the monitors for C_{SOx} and C_{NOy}
Air concentrations C_{SOx} C_{NOy}						Monitored values to represent air concentration relevant to acid deposition for sensitive water bodies (see previous discussion of air quality indicators)
Target ANC limit						
20 µeq/L: Expected to protect against significant losses due to fish mortality in many sensitive lakes, but will place less weight on protection against losses in aquatic diversity, and will be less protective against acidification episodes 50 µeq/L: Expected to protect against significant mortality in aquatic organisms and loss of fish health and biodiversity in sensitive lakes and streams, including losses due to acidification episodes, and will give weight to considerations of uncertainties in the time to recovery of aquatic ecosystems >50 µeq/L: May provide additional protection beyond 50 µeq/L against declines in fitness of sensitive species (e.g. brook trout, zooplankton), however, overall heath of aquatic communities may not be impacted						
Target for the percentage of water bodies to protect						
Options for selecting a percentile of the waterbodies to protect are informed by comparing levels of protection at alternate ANC levels given spatial aggregation options #1, 2a, 2b and 2d of the form. The number of lakes that would be protected to and ANC 50 and 20 µeq/L are quantified , and the spatial distribution of those lakes that would not receive protection is illustrated, given the 90^{th}, 75^{th} and 50^{th} percentile of the distribution of the critical loads for each population (as defined by the options).						